Integrated Solar Combined Cycle: A Hybrid Energy System Case Study

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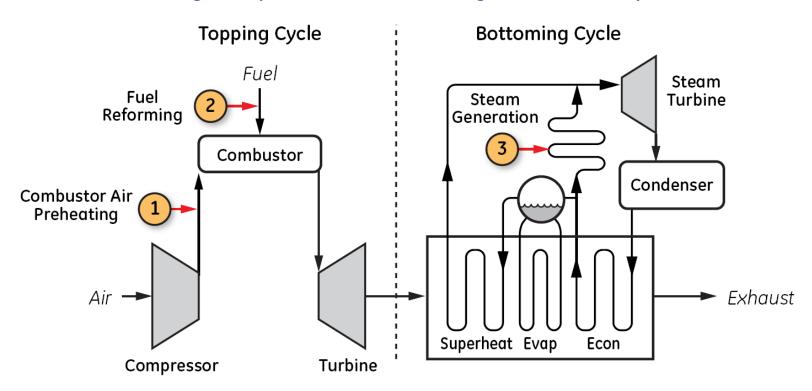




Artist Rendition of FlexEfficiency*50 with Integrated Solar Thermal and Wind

The ISCC concept: hybridize solar thermal energy with a natural gas combined cycle power plant

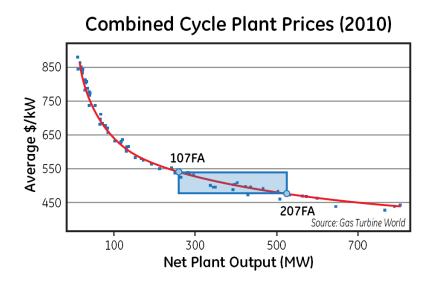
Three places where thermal energy can be advantageously added to a natural gas combined cycle:

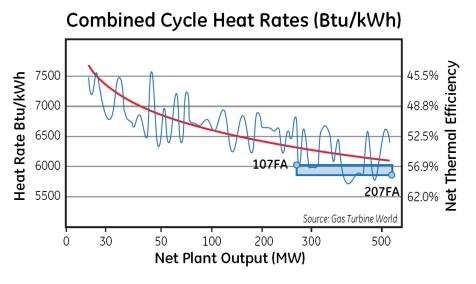




Potential benefits of ISCC hybridization

- 1. Reduces CAPEX of solar thermal-to-power conversion
 - Leverages existing power block equipment
 - Access to larger power block equipment (economy of scale)
- 2. Increases efficiency of solar thermal-to-power conversion
 - Access to larger & more efficient turbomachinery
 - Use fossil energy for the high-temperature heat addition







Potential benefits of ISCC hybridization

- 3. Increases capacity factor of solar thermal-to-power conversion
 - Natural gas is used to control power output
 - Thermal energy storage not a requirement
- 4. Cleaner power
 - Solar reduces natural gas consumption and CO2 production
 - Mitigates duct firing emissions
 - Can move plant up dispatch list

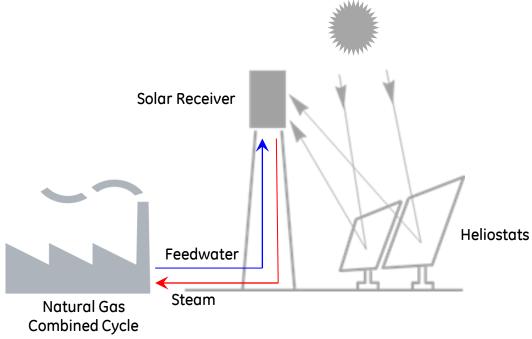




eSolar Sierra Demonstration Site, Lancaster, CA

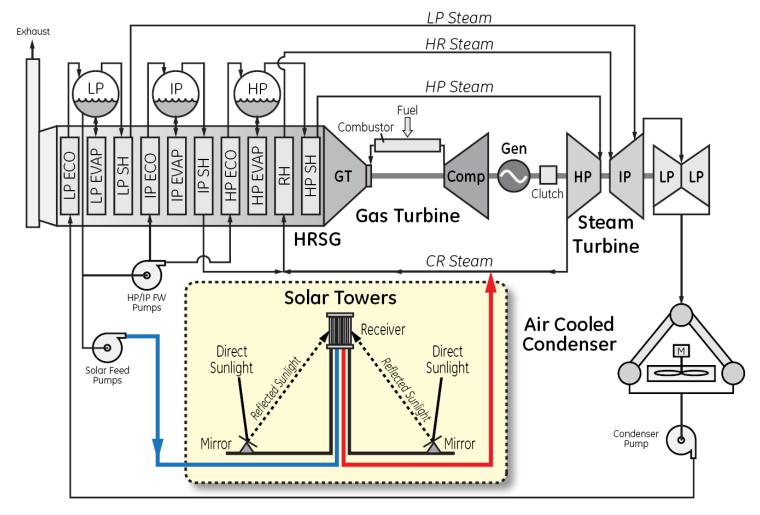
GE's direct steam ISCC product

- Concentrated solar energy is used to make steam
- Solar steam is integrated into the steam turbine system of a natural gas combined cycle power plant





Direct steam ISCC simplified diagram





ISCC Equipment



Smaller footprint, improved serviceability



Gas turbine



> 40% SC efficiency Advanced compressor & turbine design







> 40% shaft efficiency, 3-casing HP/IP/ 2-flow LP

Integrated approach

Plant/heliostat controls







Reduced site assembly, full grid code capability



eSolar.

Towers & heliostat fields



Scalable Modular Design



Digital architecture, performance seeking algorithms

FlexEfficiency* 50 Combined Cycle Power Plant



eSolar heliostat technology



Pre-fab mirror frames, standard shipping container





Simple, linear field design with no foundations







5-MW Sierra Commercial Demonstration Unit

- Proven technology demonstrated at scale
- On-line since 2009 in Lancaster, CA
- Larger installations through modular replication



eSolar Sierra Demonstration Site, Lancaster, CA





Teaming For Success



- Alliance between proven solar and power generation technology providers
- Scalable, modular designs for cost-effective utility-scale
 CSP and ISCC projects
- Broad capabilities to provide solutions for ISCC and CSP projects
- ISCC configuration offers additional output, reliable capacity and record efficiency



Single Point Contact for ISCC Applications



Hybrid Energy Systems observations

- Plant output(s) should be controllable
- Must demonstrate that hybridization will not disrupt operations and revenue
- Clearly account for operational profile & maintenance schedule of both systems
- Single integrator/turnkey provider may be necessary until hybrid system is mature, proven, and has clean interface
- Performance guarantees are challenging for hybrid systems
- Incentives and project structures will likely be complex



